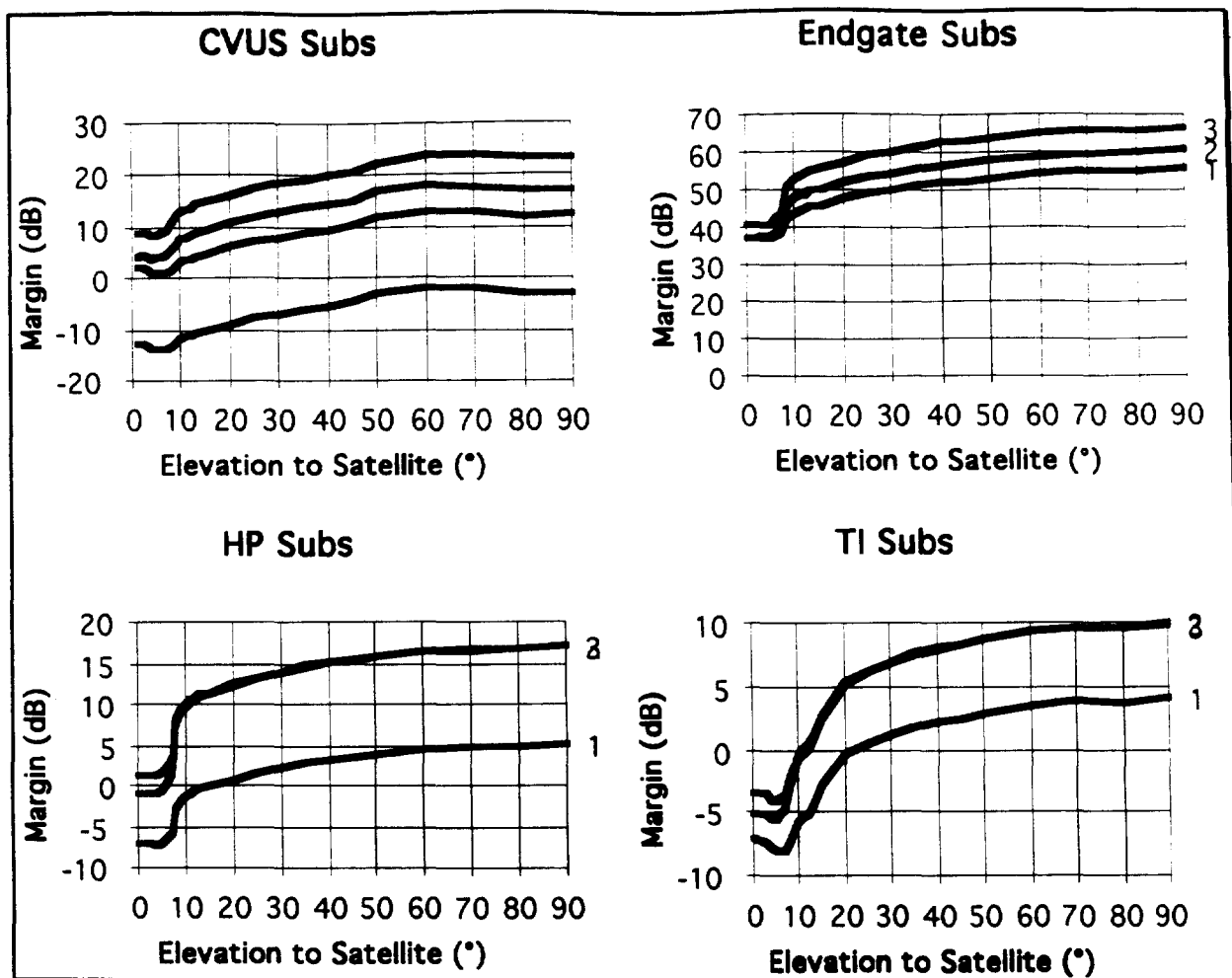**Figure 5-3. Interference from LMDS Hubs into a TDRS receiver as a function of elevation angle of the TDRS**

Figure 5-4. Interference from LMDS Subscribers into a TDRS receiver as a function of elevation angle of the TDRS

5.3 Impact of the proposed EIRP mask on TDRS

The Third NPRM proposed an EIRP limit on LMDS systems in the form of a maximum EIRP expressed in terms of dBW/MHz/km^2 (see §4.2). This EIRP mask was evaluated with respect to the levels of interference that would be received by a TDRS satellite receiver as a function of elevation angle from the LMDS emitters for Rain Zones 1, 2 & 3, with the results given in Figure 5-6.

As can be seen in the figure, unacceptable interference is produced at TDRS elevation angles from 0° to 7° in all three rain zones.
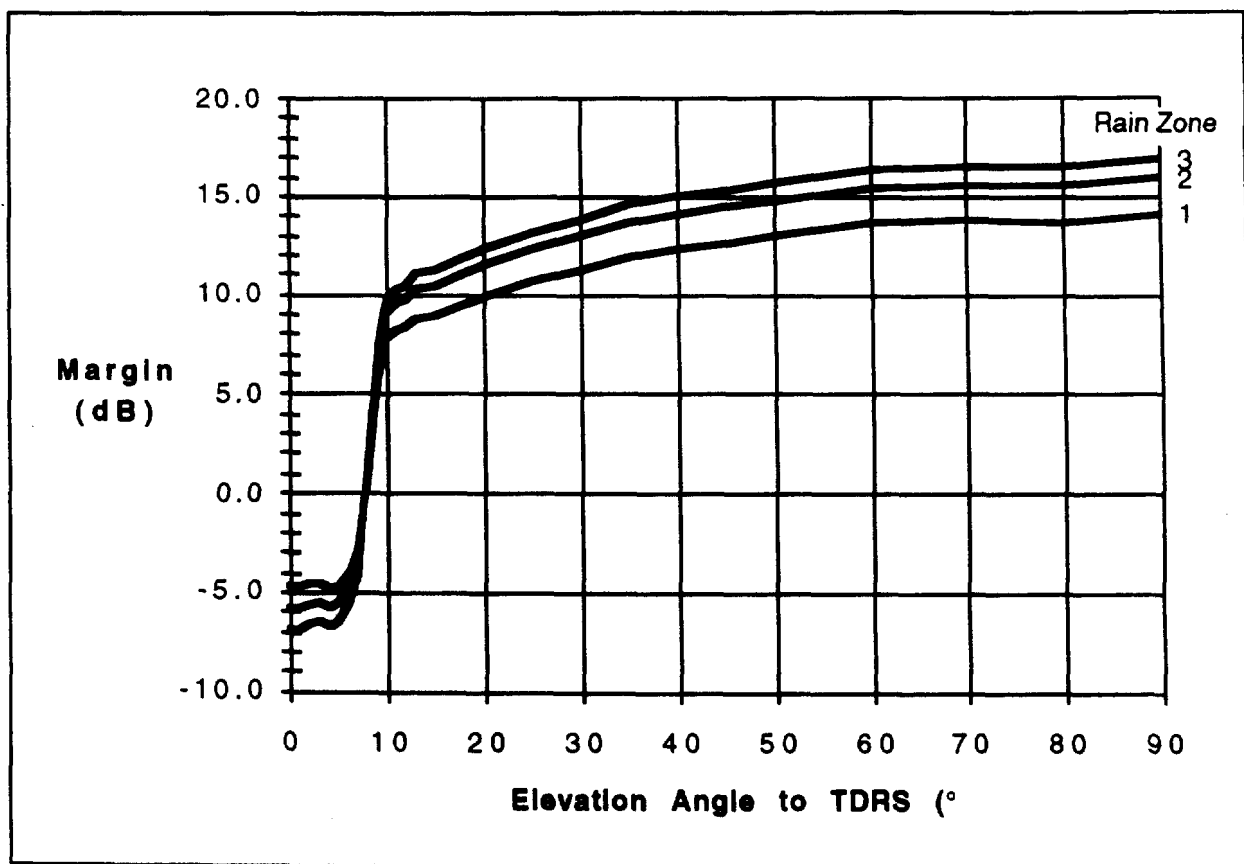
Figure 5-5. Interference impact of EIRP Mask on TDRS

5.4 Comparison to the Canadian study

A Canadian study (Doc. WP 9D-) of interference from LMCS, an LMDS-like system, found it was possible , in some conditions for LMCS to exceed the TDRS interference criteria and in other cases to exactly meet the criteria. Most situations modeled were acceptable. The LMCS system that was modeled, however, transmitted a relatively low power level system. A comparison between the LMCS systems and the CVUS and TI systems is given in the following table:

The Canadian System A parameters are essentially identical the CVUS 1 dB(W/MHz) hub case shown in Figure 5-3 and the CVUS subscriber case in Figure 5-4, differing primarily in the 1.9° hub down angle for the Canadian system (1° used in this study). The LMCS "B" parameters, which were originally considered to represent a TI-like system, actually are quite different and produce significantly lower levels of interference than those calculated using the parameters provided by TI for this study.

A comparison of the Canadian results to an analysis using the approach given in §5.2 of this report but using similar parameters to the Canadian report, yielded results that matched within 1-2 dB.

	Canadian LMCS System A Hub	CVUS Hub	Canadian LMCS System B Hub	TI Hub
EIRP/MHz	1	1	-11	7
Cell Radius, km	4.9	4.8	5.5	5
Hub down angle, deg	-1.9	-1	-2.3	-2
	Canadian LMCS System A Sub	CVUS Sub	Canadian LMCS System B Sub	TI Sub
EIRP/MHz	10	10	8.8	17
Cell Radius	4.9	4.8	5.5	5

Figure 5-6. Comparison of Canadian LMCS and US systems

16

6. Impact of modeled LMDS systems on Proximity Operations receivers

6.1 Effects of single, high powered LMDS emitters

As an initial step in the analysis of interference into the POCS receivers, the impact of a single LMDS transmitter pointed directly at the POCS was investigated. Figure 6-1 presents a calculation of the interference power received, assuming that the LMDS subscriber has an antenna elevation angle of 1° and the POCS is at an altitude of 280 km. The elevation of the POCS from the LMDS transmitter was assumed to be 3 ° (1° in the case of the HP Subscriber).

As can be seen in the table, individual CVUS Hub transmitters, exceed the interference criteria when peaking is considered, and approximately equal the criteria without peaking.

	CVUS Hub	CVUS Sub	CVUS Hub	CVUS Sub	TI Hub	TI Sub	END Hub	END Sub	HP Hub	HP Sub
EIRPo (dBW/MHz)	25.0	25.0	1.0	10.0	7.0	17.0	-3.3	-9.7	-8.0	18.0
Antenna elevation	-1.0	1.0	-1.0	1.0	-2.0	1.0	-1.0	1.0	-0.3	1.0
Elevation to POCS	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	1.0
LMDS antenna discrimination (dB)	-4.5	-3.0	-4.5	-3.0	-4.7	-3.2	-26.9	-12.0	-3.1	0.0
Space loss to POCS	-185.2	-185.2	-185.2	-185.2	-185.2	-185.2	-185.2	-185.2	-185.2	-186.7
Atmospheric loss(dB)	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-12.0
Polarization loss (dB)	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0
POCS Antenna gain (dBi)	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5
Interference received (dBW/MHz	-141.2	-139.7	-165.2	-156.2	-159.4	-147.9	-191.8	-183.4	-172.7	-151.2
Interference criteria	-139.7	-139.7	-139.7	-139.7	-139.7	-139.7	-139.7	-139.7	-139.7	-139.7
Margin, no peaking (dB)	1.5	0.0	25.5	16.5	19.7	8.2	52.1	43.7	33.0	11.5
Peaking factors	10.0									
Margin, with peaking	-8.5									

Figure 6-1. Impact of a single LMDS transmitter on a POCS receiver

6.2 Aggregate effect of LMDS Hubs on a POCS

The POCS receives short range communications within the immediate vicinity of a space station assumed to be at a 350 km altitude. The receiving antenna 5.9° wide mainbeam may point in any direction, including toward the Earth. The computer model points the POCS 5.9° wide beam boresight to intersect the Earth at a specified angle of elevation. The POCS 3 dB beam area intersection with the Earth is then fully populated with LMDS cells equally spaced using the cell radius from Figure 5-2. The necessary pointing angle, slant range, antenna gain, and clear-air atmospheric loss calculations (ITU-R PN.676-2) are made to determine the interfering power contribution from each cell. The aggregate interference power for 100% LMDS deployment is accumulated for a particular angle of elevation of the POCS mainbeam boresight. The process is repeated for elevation angles from 0° to 90°.

For a 90° elevation angle, the POCS beam intersection with the Earth is a circle of about 36 km diameter. A 100% "fill" of the beam area would be appropriate for high elevation angles.

For low elevation angles, the beam intersection takes on an elongated elliptical area of about 160 km wide and up to 1100 km long. A 33% "fill" of the beam area may be more appropriate for low elevation angles and is estimated by assuming LMDS interference levels are reduced by $10 \log(33\%/100\%) = -4.8$ dB.

The results for LMDS Hub transmissions were made on the basis of one co-channel signal per cell and are shown on Figure 6-2. The curves correspond to the labeled rain zone areas (1, 2, 3-5) from Table 5-2 and are shown for 33% fill of beam area.

See Appendix A, Figures A-3 and A-4 used in deriving the interference margin plots shown in Figures 6-2 and 6-3. The margins in the figures are for a 33% fill of the satellite beam footprint area.
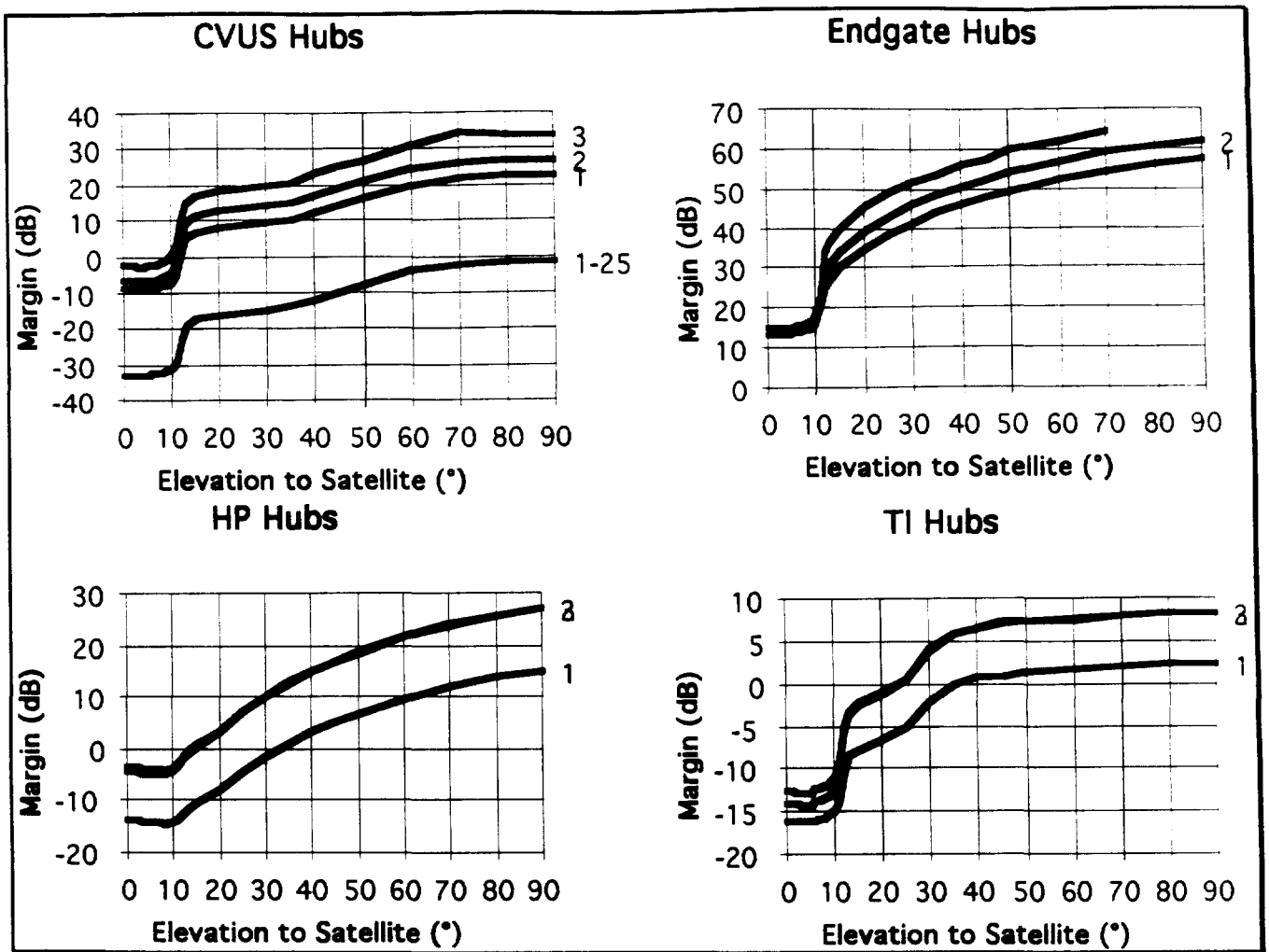
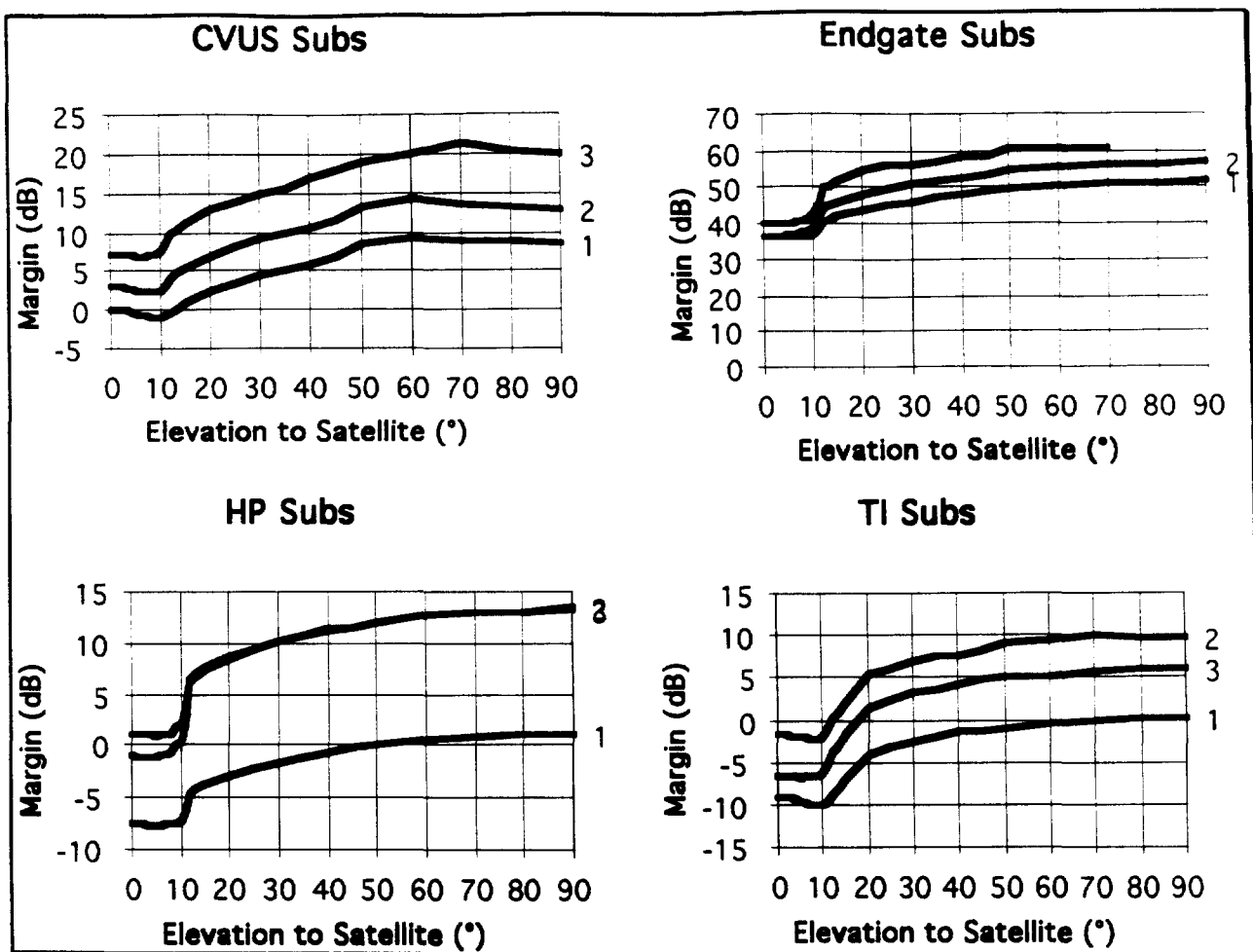**Figure 6-2. Hub to POCS interference as a function of elevation angle to the POCS**

Figure 6-3. Graph of Subscriber to POCS interference as a function of elevation angle to the POCS

6.3 Aggregate Interference Effect of LMDS on POCS for Selected Metropolitan Areas

To further understand the effect of LMDS aggregate interference on the POCS space system, a MATLAB computer simulation program was developed to perform Monte Carlo simulations of LMDS interference originating from systems in specific metropolitan statistical areas (MSAs) such as New York and Miami. A description of the simulation program and the assumptions used in the analyses are given in Appendix B.

Using the simulation program, I/N margins were calculated for various beam elevation angles (i.e. beam footprint sizes) and LMDS coverage of the New York (rain zone 2) and Miami (rain zone 1) MSAs. For reference, beam footprint sizes and MSA areas used in the analyses are as follows:

Beam Boresight Elevation Angle (deg)	3 dB Beam Footprint Size @ 350 km;5.9° HPBW(km^2)
0°	141540
5°	151300
15°	39900
20°	19587
30°	7212
40°	3612
New York MSA Area	19825
Miami MSA Area	8196

Figure 6-4 shows the I/N margins at the POCS receiver resulting from CVUS subscribers operating at a T1 data rate and maximum EIRP level of 10 dBW. Curves are shown for various LMDS coverage "effective areas" where the effective area is defined to be that area in the beam footprint occupied by LMDS cells. The number of LMDS cells is found by dividing the effective area by the LMDS cell area. The concept of effective area is used to take into account the fact that beam footprints (especially large ones that occur at low elevation angles) will typically not be completely saturated with LMDS cells. The figure reflects three different methods of computing effective area (see Appendix B for a detailed explanation of these methods). A brief description will be given here, since it is important in understanding the graphs. Refer to Figure 6-4.

1) curves labeled "100% beam fill" use option A and the effective area is simply the entire 3 dB beam footprint area (i.e. the entire footprint is assumed to be populated with LMDS cells).

Hence, these generally give the lowest margins especially at low elevation angles where the footprints are large. Note that the (100% Beam fill RZ 1) curve in Figure 6-4 is worse than that for RZ 2 due to the smaller cell sizes in RZ 1 and hence larger number of cells in the footprint.

2) curves labeled "New York MSA only" or "Miami MSA only" use option B in which the effective area is taken to be the entire MSA area *as long as the beam footprint is larger than the MSA*. The rest of the footprint is assumed to be *completely empty* of LMDS cells. *If the beam footprint, on the other hand, is smaller than the MSA itself, the effective area is taken to be equal to the beam area even if a 100% MSA coverage is specified*. This typically happens at higher elevation angles. For example, the New York MSA is about 19800 km^2 in area. At 20° elevation, the beam footprint is about 19600 km^2 in area. Hence, at 20° elevation, the effective area is taken to be the footprint area of 19600 km^2. At angles above 20°, the effective areas for the 100% RZ2, NY only, and NY+33% curves are therefore simply the footprint area itself which is why they nearly overlap one another. The same effect occurs for the Miami curves (100% beam fill RZ 1, Miami only, Miami + 33%) at 30° elevation where the footprint size is 7200 km^2 and the Miami MSA area is 8200 km^2.

3) curves labeled "NY MSA + 33%" and "Miami MSA + 33%" use option C which is analogous to the Canadian approach for computing effective area. Again, if the beam footprint is larger than the MSA (which it is at low elevation angles), the effective area is taken to be the entire MSA + *33% of the remaining footprint area outside the MSA*. Like option B, however, if the beam footprint is smaller than the MSA, then the effective area is simply taken to be the beam footprint area itself. Again, this typically occurs at the higher elevation angles where the footprints are smaller. Hence, at the higher elevation angles, the I/N margin values for a particular MSA will generally be the same for *all three options* as indicated in Figure 6-4 for the New York and Miami MSAs.

Figure 6-4 indicates that CV subscribers with 10 dBW EIRP produce margins that are generally positive in all cases except the 100% beam fill case in rain zone 1. Figure B-1 in Appendix B, however, shows that when the proposed CV EIRP level of 25 dBW/MHz is used for the T1 subscribers, negative margins result for all cases with some reaching -15 dB. In analyzing the T1 subscriber interference, 15 randomly located T1 interferes per cell was assumed based on a 14.7 MHz space receive bandwidth and 1 MHz T1 subscriber bandwidth. In some simulation runs, the effect of deliberately forcing one T1 interferer per cell into azimuth (not necessarily elevation) alignment with the satellite was examined. Figure B-2 in Appendix B shows this case. As seen from the 100% beam fill curve, the impact is apparent only at the lower elevation angles where there is about a 5 dB drop in margin.

Figure 6-5 shows the I/N margins resulting from CV hubs transmitting 20 MHz FM/TV signals at 7.0 dBW EIRP. Note that negative margins occur in the 0°-5° elevation range for the lower two curves. Both of these are for the NY MSA+ 33% effective area case. The hub scatter curve assumes signal reflections off the ground from the hub terminals which add to the interference into the space receiver. The 10 dB peaking curve assumes a 1 MHz space system receive bandwidth which is being interfered with by the wideband 20 MHz FM/TV signals. Under these conditions of a narrowband victim bandwidth, the shape of the FM signal power spectral density becomes important and a 10 dB factor to account for the non-flat spectrum is applied.
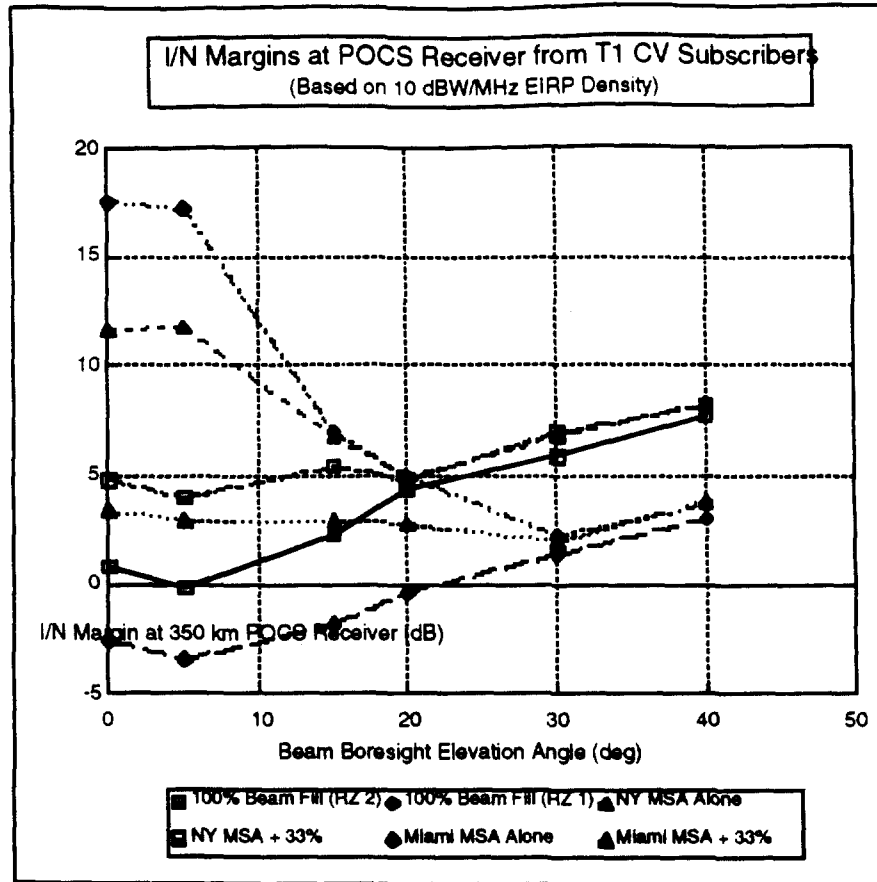
Figure B-3 in Appendix B shows the result of increasing the hub EIRP to 40 dBW based on the proposed CV EIRP density of 25 dBW/MHz. In this case, severe interference is experienced over all elevation angles with margins going down to as much as -30 dB.

Figures 6-6 and 6-7 show the results for HP hubs and HP T1 subscribers, respectively. The 60 Mbps hubs operating at 8 dBW EIRP are seen to cause unacceptable interference up to 25° elevation for all cases. The T1 subscribers are also seen to cause negative margins in some situations. In Figure 6-7, note in particular the curve for Miami MSA only where 1 km radius cells are specified. For this curve, negative margins occur even at relatively high elevation angles. For example, negative margins occur at $30°$ and $40°$ elevation where the footprint sizes (7212 km^2 and 3612 km^2) are smaller than the Miami MSA.

Figure 6-8 shows the results for TI subscribers operating at 3.3 Mbps (2.5 MHZ) and 40 Mbps (30 MHZ) in the Miami area where the TI cell size is 2.5 km. Again, the relatively small cell size and low discrimination of the subscriber antennas causes significant interference up to $40°$ elevation and beyond. The New York MSA cases shown in Figure B-4 in Appendix B also show significant negative margins, although to a lesser degree due to the larger 5 km cell size. Like the CV case, the effect of forcing one of the 5 (2.5 MHZ) TI subscribers per cell into azimuth alignment with the satellite was examined. Figure B-5 shows this case. For example, by comparing the Miami+33% (2.5 MHZ) curves in Figures 6-8 and B-5, it is seen that forcing one interferer per cell into alignment causes about a 9 dB drop in margin.

Finally Figure 6-9 shows the interference due to the TI 200 Mbps (60 MHZ) hubs operating at 25 dBW EIRP in both the New York (5 km cells) and Miami (2.5 km cells) areas. For all four cases, severe interference is produced at the proximity operations space receiver over a broad elevation angle range. Interference from the lower power 20 dBW (65 Mbps/40 MHZ) TI hubs is also excessive as shown in Figure B-6 of Appendix B.

Because the ENDGATE LMDS system showed relatively high I/N margins even for 100% beam fill, plots for this system were not generated.

Figure 6-4. CV Subscriber T1 Transmission
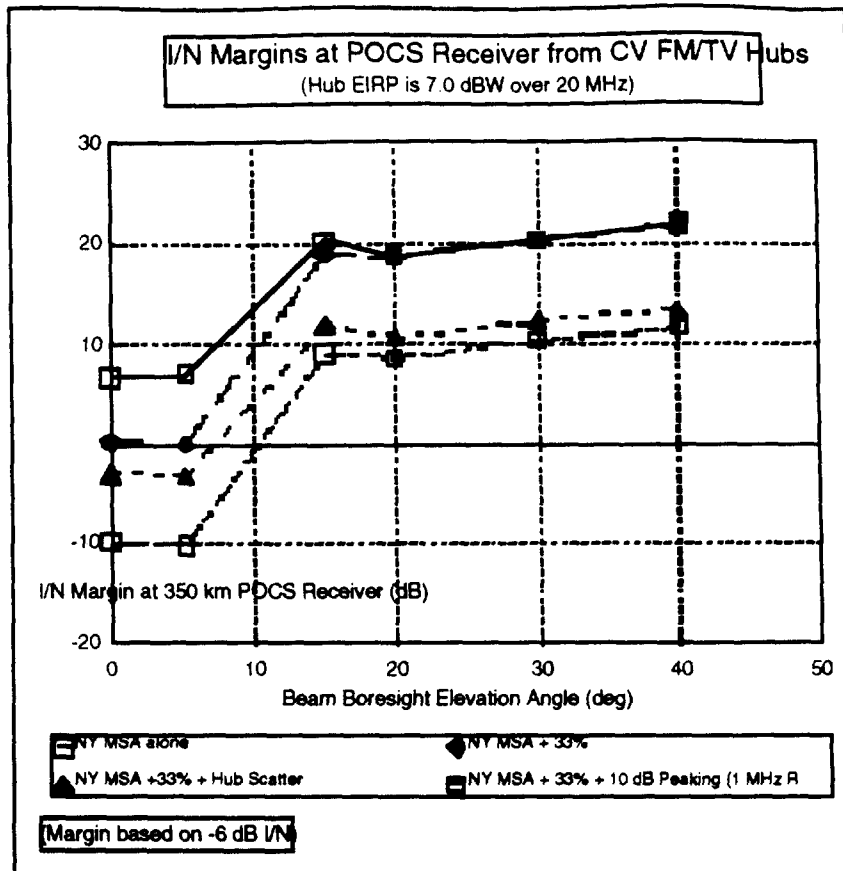
Figure 6-5. CVUS Hub FM/TV Transmission

I/N Margins at POCS Receiver from HP T1 Subscribers
(EIRP = 14 dBW over 1 MHz BW)

Beam Boresight Elevation Angle (deg)

I/N Margin at 350 km POCS Receiver (dB)

- ■ 100% Beam Fill (2km cells)
- ● NY MSA + 33% (2km cells)
- ▲ NY MSA Only (2km cells)
- ◘ Miami MSA Only (1km cells)
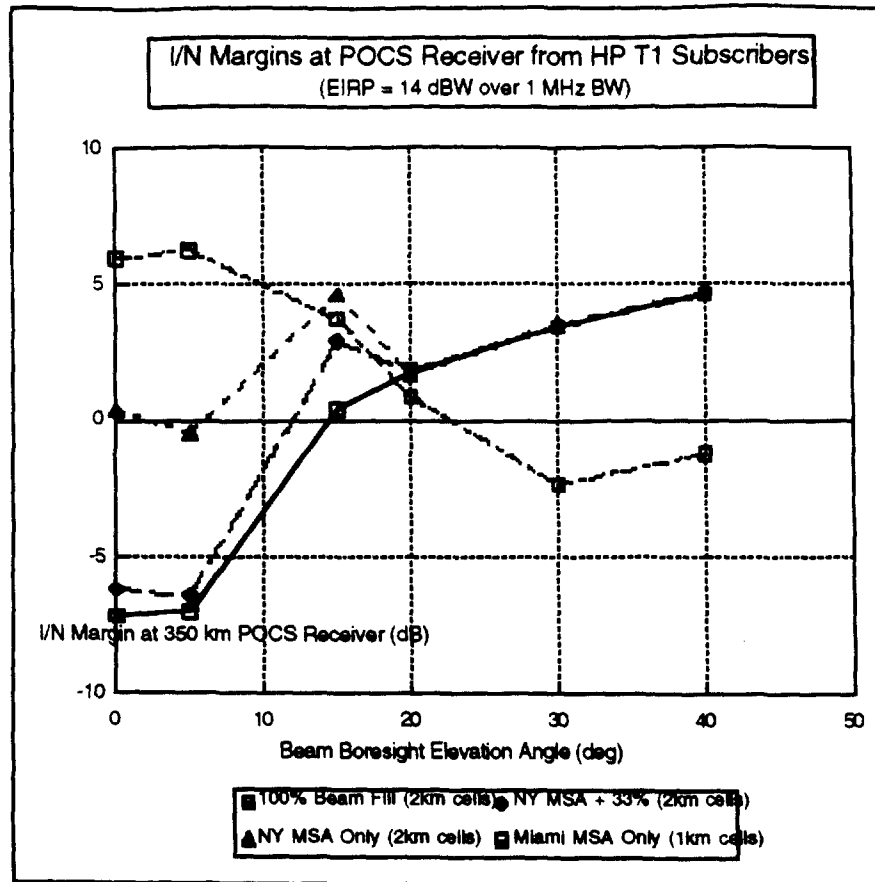
Figure 6-6. HP Subscriber T1 Transmission

26
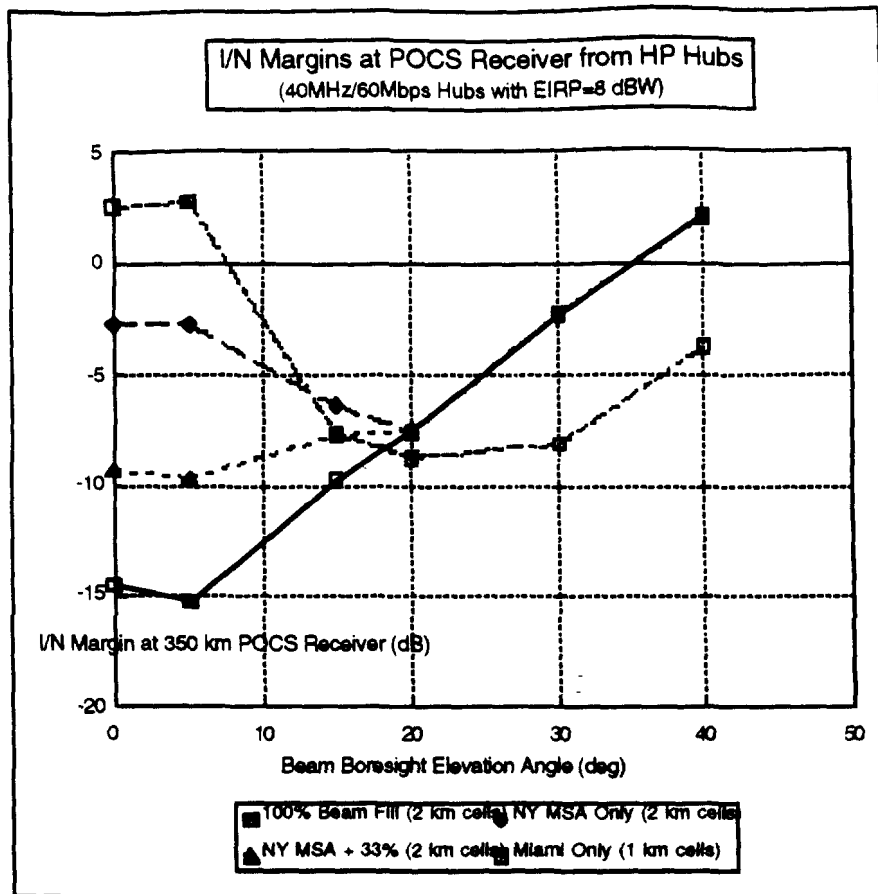
Figure 6-7. HP Hub 40 MHz/60 Mbps Transmission
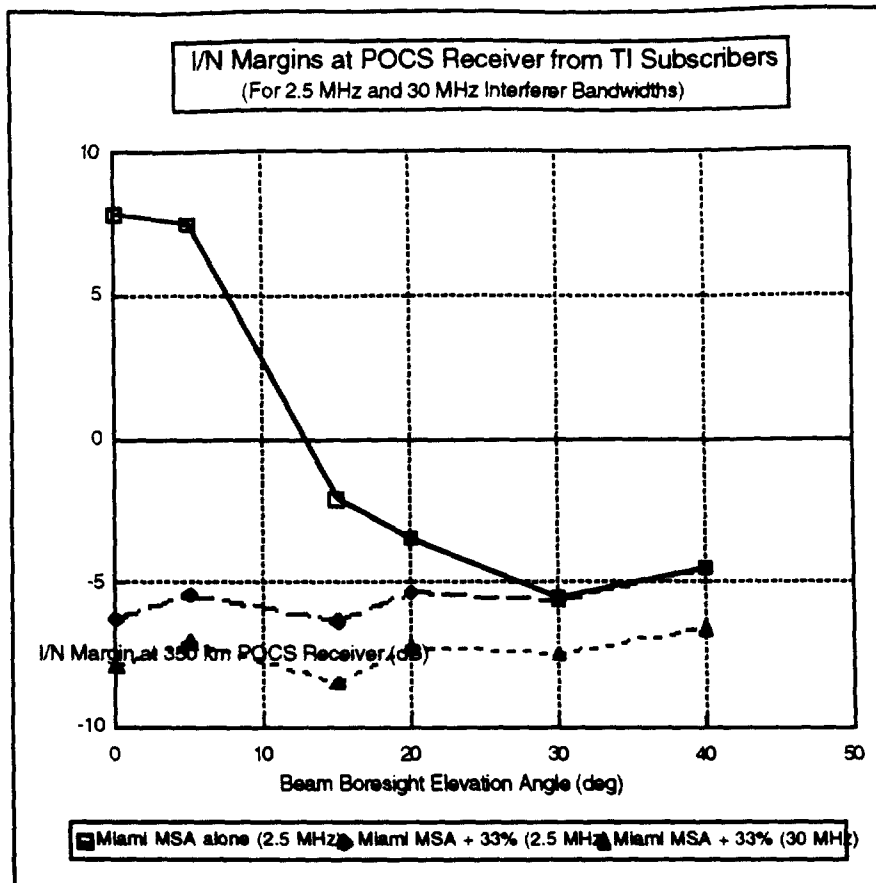
Figure 6-8. TI Subscriber 2.5 & 30 MHz Transmissions
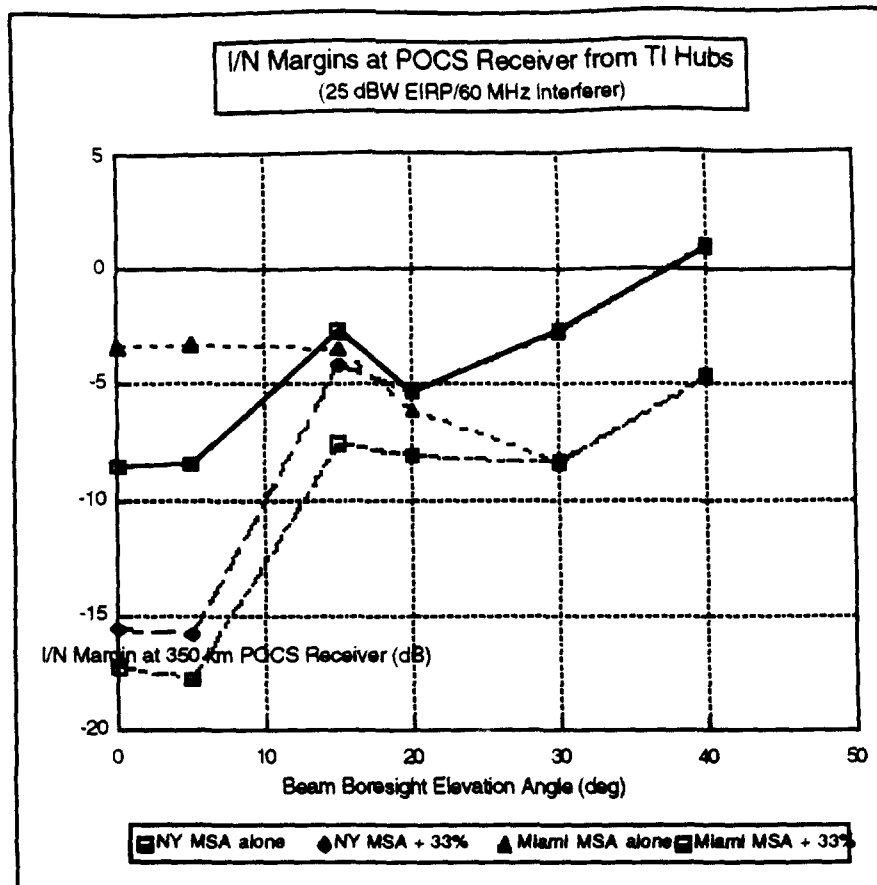
Figure 6-9. TI Hub 25 dBW EIRP/60 MHz Transmission

6.4 Impact of the proposed EIRP mask on POCS

The Third NPRM proposed an EIRP limit on LMDS systems in the form of a maximum EIRP expressed in terms of $dBW/MHz/km^2$ (see §4.2). This EIRP mask was evaluated with respect to the levels of interference that would be received by a POCS satellites receiver as a function of elevation angle from the LMDS emitters for Rain Zones 1, 2 & 3, with the results given in Figure 6-10.

As can be seen in the figure, interference is produced at elevation angles from $0°$ to $11°$ in all three rain zones.
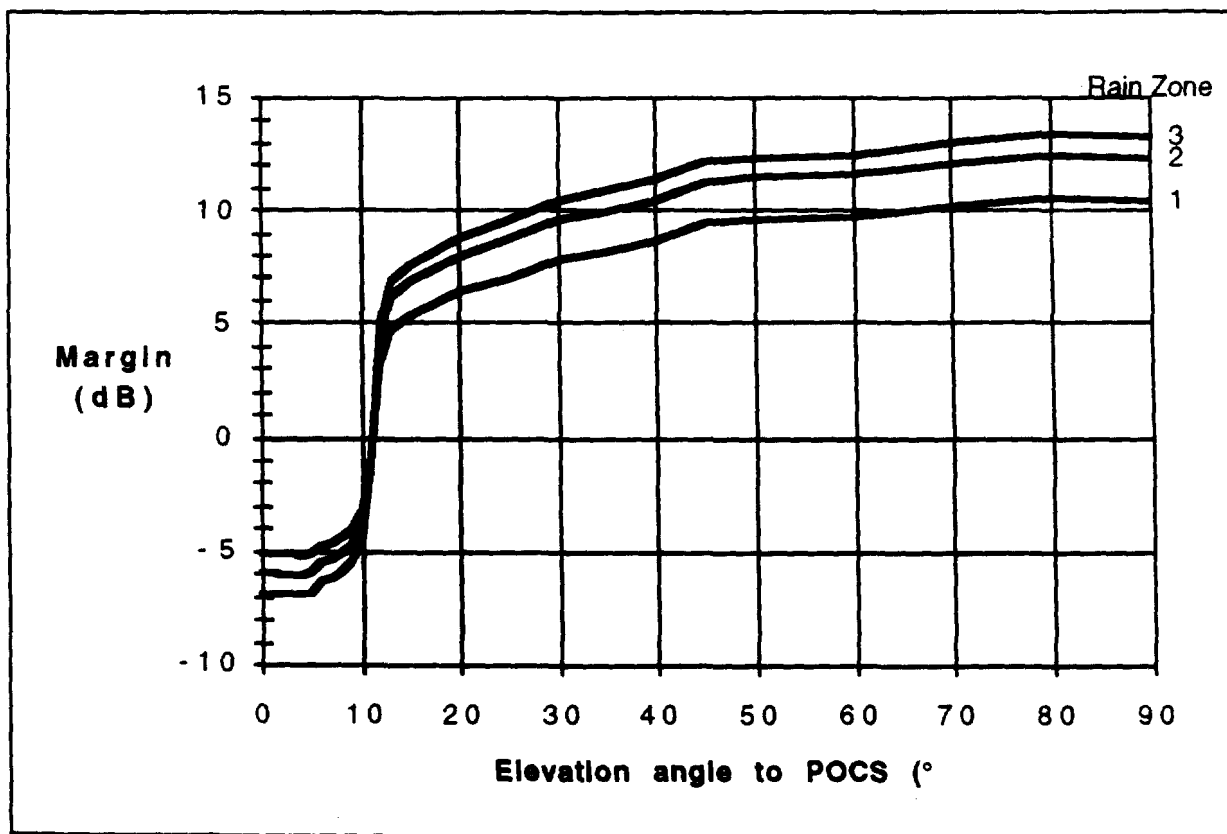
Figure 6-10. Interference impact of EIRP Mask on POCS

6.5 Results of the Canadian study

An analysis was prepared by Canada of interference from the LMCS system (similar to LMDS) into the POCS (SFCG 15-39). The modeled LMCS system was of relatively low power, as discussed in §5.4.

Even for these low powered transmitters, the Canadian report concluded that the POCS would receive interference.

30

7. Impact of modeled LMDS systems on EES downlinks

The Negotiated Rulemaking Committee for LMDS concluded that sharing between LMDS and Earth stations operating with low-Earth orbit satellites was not feasible within the same geographical area. In the case of EES downlinks, the Earth stations are receiving Earth stations rather than transmitting stations as is the case in the 27.5 - 30.0 GHz band, but the basic concepts remain the same. The LMDS system, by its ubiquity, would make it impracticable to coordinate Earth station locations within an LMDS service area.

8. Conclusions

NASA has undertaken an intensive study to assess the feasibility of sharing between NASA space services and LMDS services below 27.5 GHz. The study has concentrated on the potential impact to Data Relay Satellite Systems and Proximity Operations Communications Systems, as well as a limited assessment of the potential impact to Earth Exploration Satellite services. Our analyses show that unacceptable interference would result from both LMDS hub and LMDS subscriber transmissions for three of the four LMDS proponent systems currently before the FCC.

LMDS system	Interference margin	
	TDRS	POCS
CVUS Hub	-9.4	-9.0
CVUS Sub	1.1	-1.1
CVUS Hub (25 dBW/MHz)	-33.4	-32.9
CVUS Sub (25 dBW/MHz)	-13.9	-16.1
Endgate Hub	15.5	13.3
Endgate Sub	36.9	36.2
HP Hub	-13.9	-14.4
HP Sub	-7.3	-7.7
TI Hub	-16.5	-16.3
TI Sub	-8.2	-10.1
EIRP mask	-7.0	-7.0

Figure 8-1. Interference margin summary

Figure 8-1 shows the interference margins for TDRS and POCS from data in figures 5-3, 5-4 and 6-2, 6-3. Significant negative margins were found for the LMDS systems proposed by CellularVision, Hewlett Packard and Texas Instrument. Only the Endgate system parameters resulted in positive margins for the TDRS and POCS systems.

While interference is most severe for elevation angles to the satellite below 10°, unacceptable interference is found for elevations to 50° under several cases (e.g. interference into POCS from HP and TI subscribers in high rain areas of the country).

NASA concludes that sharing between NASA space services and LMDS systems is not feasible in the band below 27.5 GHz. We further conclude that due to the magnitude of unacceptable interference resulting from three of the four LMDS system types currently before the FCC, no rules acceptable to all parties could be drafted which would guarantee protection of NASA space services from harmful interference.

Appendix A

Results of detailed analyses of interference

Elev.	CV Hub 1	CV Hub 2	CV Hub 3	CV Hub 1-25	End Hub 1	End Hub 2	End Hub 3	HP Hub 1	HP Hub 2	HP Hub 3	TI Hub 1	TI Hub 2	TI Hub 3
0	-.9	-.7	-.3	-.33	16.2	17.6	21.3	-12.1	-2.1	-3.4	-16.0	-12.3	-14.0
1	-9.1	-6.7	-2.5	-33.1	16.2	17.6	21.2	-12.2	-2.2	-3.5	-16.1	-12.4	-14.0
2	-9.1	-6.6	-2.5	-33.1	16.2	17.7	21.2	-12.3	-2.3	-3.6	-16.0	-12.3	-13.9
3	-9.1	-6.6	-2.5	-33.1	16.0	17.8	21.2	-12.6	-2.5	-3.7	-16.1	-12.3	-13.8
4	-9.4	-7.0	-2.7	-33.4	15.6	17.3	21.0	-13.4	-3.2	-4.3	-16.5	-12.6	-14.1
5	-9.2	-6.6	-2.5	-33.2	15.5	17.6	21.2	-13.7	-3.4	-4.4	-16.3	-12.5	-13.9
6	-8.6	-5.8	-1.4	-32.6	15.8	18.1	22.2	-13.8	-3.3	-4.2	-15.8	-11.9	-13.3
7	-7.7	-4.8	-0.4	-31.7	16.2	18.7	23.2	-13.9	-3.3	-4.1	-15.1	-11.1	-12.3
8	-4.6	-1.1	3.9	-28.6	17.8	21.2	26.4	-13.2	-2.3	-2.9	-12.6	-7.9	-8.6
9	1.6	5.5	10.5	-22.4	19.6	23.4	28.5	-11.8	-0.7	-1.2	-8.6	-3.5	-4.0
10	6.8	11.0	16.4	-17.2	20.9	24.9	30.1	-10.1	1.2	0.8	-6.2	-0.9	-1.3
11	9.4	13.8	19.2	-14.6	22.0	26.0	31.4	-8.7	2.7	2.4	-5.2	0.3	0.0
12	9.7	14.1	19.6	-14.3	22.8	26.9	32.2	-8.0	3.4	3.1	-5.0	0.5	0.2
13	10.1	14.7	20.1	-13.9	23.9	28.2	33.5	-7.5	4.1	3.8	-4.5	1.0	0.7
15	10.2	14.8	20.4	-13.8	25.2	29.5	35.0	-7.3	4.2	3.9	-4.4	1.2	0.9
20	11.2	15.9	21.4	-12.8	28.5	32.9	38.3	-5.3	6.4	6.3	-3.4	2.2	2.0
25	12.0	16.7	22.5	-12.0	31.1	35.4	41.2	-2.7	9.1	8.9	-1.7	4.0	3.9
30	12.6	17.4	23.2	-11.4	33.2	37.6	43.1	-0.7	11.1	10.9	1.4	7.2	7.0
35	13.4	18.3	23.9	-10.6	35.3	39.7	45.3	1.3	13.1	13.0	3.6	9.4	9.3
40	15.5	20.4	26.0	-8.5	36.8	41.0	47.3	2.8	14.6	14.5	4.1	9.9	9.8
45	17.4	22.2	27.9	-6.6	38.0	42.3	48.3	3.9	15.8	15.7	4.3	10.1	10.1
50	19.5	24.3	29.9	-4.5	39.3	43.7	49.9	5.1	17.0	16.9	4.6	10.5	10.4
60	23.6	28.5	34.4	-0.4	41.6	46.0	52.3	7.3	19.3	19.2	5.3	11.2	11.1
70	25.3	30.1	36.4	1.3	43.0	47.3	53.4	8.7	20.6	20.5	5.6	11.4	11.3
80	25.1	29.9	36.3	1.1	44.2	48.5	54.6	9.7	21.7	21.6	5.5	11.3	11.3
90	25.6	30.5	36.7	1.6	45.6	50.1	55.7	11.1	23.0	23.0	5.9	11.7	11.6

Figure A-1. Aggregate Interference from LMDS Hubs into a
TDRS Satellite Receiver

Elev	CV Sub 1	CV Sub 2	CV Sub 3	CV Sub 1-25	End sub 1	End sub 2	End sub 3	HP Sub 1	HP Sub 2	HP Sub 3	TI Sub 1	TI Sub 2	TI Sub 3
0	2.1	4.5	8.7	-12.9	37.1	37.2	40.5	-7.1	1.3	-1.1	-7.1	-3.5	-5.2
1	2.1	4.5	8.7	-12.9	37.0	37.2	40.5	-7.1	1.2	-1.1	-7.2	-3.5	-5.2
2	2.0	4.5	8.7	-13.0	37.1	37.4	40.5	-7.0	1.3	-1.0	-7.2	-3.5	-5.1
3	1.8	4.4	8.7	-13.2	37.1	37.7	40.6	-7.0	1.4	-1.0	-7.4	-3.6	-5.1
4	1.3	3.9	8.3	-13.7	36.9	37.4	40.5	-7.3	1.2	-1.1	-8.0	-4.1	-5.5
5	1.1	4.0	8.3	-13.9	37.0	38.1	40.8	-7.2	1.6	-0.6	-8.2	-4.1	-5.5
6	1.2	4.3	8.9	-13.8	37.8	38.7	42.7	-6.5	2.4	0.3	-8.1	-3.9	-5.1
7	1.1	4.5	9.2	-13.9	38.8	40.2	43.9	-5.8	3.5	1.6	-8.1	-3.6	-4.7
8	1.9	5.8	11.1	-13.1	42.3	45.8	51.0	-3.0	7.9	7.3	-7.3	-2.2	-2.8
9	2.8	7.0	12.3	-12.2	43.3	47.1	52.3	-1.8	9.3	8.9	-6.3	-1.1	-1.5
10	3.3	7.6	13.0	-11.7	43.9	47.9	53.1	-1.3	10.0	9.7	-5.8	-0.4	-0.8
11	3.6	8.1	13.5	-11.4	44.5	48.5	53.8	-0.9	10.5	10.2	-5.3	0.1	-0.2
12	3.8	8.3	13.7	-11.2	44.8	48.9	54.1	-0.7	10.7	10.4	-5.1	0.4	0.1
13	4.4	9.0	14.4	-10.6	45.5	49.7	55.0	-0.2	11.3	11.0	-4.3	1.3	1.0
15	4.7	9.3	14.9	-10.3	46.0	50.2	55.7	-0.1	11.4	11.2	-2.9	2.7	2.4
20	6.1	10.8	16.3	-8.9	47.7	52.0	57.4	0.8	12.5	12.3	-0.2	5.4	5.2
25	7.2	11.9	17.7	-7.8	49.0	53.3	59.1	1.6	13.3	13.2	0.5	6.3	6.1
30	8.0	12.9	18.6	-7.0	50.1	54.5	60.0	2.2	13.9	13.8	1.2	6.9	6.8
35	9.0	13.8	19.4	-6.0	51.3	55.6	61.2	2.9	14.7	14.6	1.9	7.6	7.5
40	9.5	14.4	20.0	-5.5	52.0	56.3	62.5	3.3	15.2	15.1	2.3	8.1	8.0
45	10.3	15.2	20.8	-4.7	52.5	56.8	62.8	3.5	15.4	15.3	2.5	8.4	8.3
50	12.1	16.9	22.4	-2.9	53.2	57.6	63.8	3.9	15.8	15.7	2.8	8.7	8.6
60	13.2	18.0	23.9	-1.8	54.5	58.9	65.1	4.6	16.6	16.5	3.6	9.4	9.3
70	12.9	17.6	24.0	-2.1	54.9	59.3	65.4	4.8	16.7	16.6	3.8	9.6	9.5
80	12.2	17.0	23.3	-2.8	55.3	59.6	65.7	4.7	16.7	16.6	3.8	9.6	9.5
90	12.2	17.1	23.4	-2.8	56.1	60.6	66.2	5.2	17.1	17.1	4.2	9.9	9.9

Figure A-2. Aggregate Interference from LMDS subscribers into a TDRS satellite receiver

Elev	CV Hub 1	CV Hub 2	CV Hub 3	CV Hub 1-25	End Hub 1	End Hub 2	End Hub 3	HP Hub 1	HP Hub 2	HP Hub 3	TI Hub 1	TI Hub 2	TI Hub 3
0	-8.9	-6.6	-2.8	-32.9	14.9	13.3	14.9	-13.8	-3.5	-4.6	-16.1	-12.7	-14.2
1	-8.9	-6.6	-2.8	-32.9	14.9	13.3	14.9	-13.8	-3.6	-4.6	-16.1	-12.7	-14.2
2	-8.9	-6.6	-2.8	-32.9	14.9	13.3	14.9	-13.9	-3.6	-4.6	-16.1	-12.7	-14.2
3	-9.0	-6.6	-2.8	-33.0	15.2	13.3	14.9	-14.0	-3.8	-4.7	-16.2	-12.8	-14.2
4	-9.0	-6.6	-2.8	-33.0	15.2	13.4	15.0	-14.1	-3.9	-4.9	-16.2	-12.8	-14.2
5	-9.0	-6.6	-2.8	-33.0	15.3	14.0	15.4	-14.3	-4.0	-5.0	-16.3	-12.8	-14.2
6	-8.6	-6.5	-2.7	-32.6	15.3	14.1	15.8	-14.3	-4.1	-5.1	-16.0	-12.4	-13.8
7	-8.5	-6.4	-2.5	-32.5	15.5	14.3	16.0	-14.4	-4.2	-5.1	-15.9	-12.3	-13.7
8	-8.3	-5.7	-1.7	-32.3	15.8	14.6	16.4	-14.4	-4.2	-5.1	-15.8	-12.1	-13.4
9	-7.9	-5.3	-1.3	-31.9	16.1	15.1	16.8	-14.4	-3.9	-4.7	-15.3	-11.8	-13.1
10	-7.1	-4.6	0.1	-31.1	17.1	16.4	18.9	-14.2	-3.7	-4.5	-14.9	-11.1	-12.3
11	-5.3	-2.3	2.5	-29.3	20.3	21.1	22.3	-13.8	-3.1	-3.7	-13.6	-9.2	-10.2
12	0.4	4.3	9.8	-23.6	25.1	28.8	34.2	-12.9	-1.9	-2.3	-10.4	-5.2	-5.7
13	5.0	9.4	14.9	-19.0	27.1	30.9	36.5	-11.8	-0.6	-0.9	-8.5	-3.2	-3.5
15	6.9	11.4	17.1	-17.1	30.0	34.0	39.4	-10.4	0.9	0.6	-7.7	-2.2	-2.4
20	7.9	12.5	18.5	-16.1	34.9	39.2	45.5	-8.0	3.5	3.3	-6.8	-1.1	-1.3
25	8.7	13.3	19.0	-15.3	38.6	42.9	49.2	-4.4	7.3	7.1	-5.1	0.6	0.4
30	9.3	14.1	19.9	-14.7	41.3	46.0	51.4	-1.5	10.3	10.2	-2.0	3.9	3.8
35	10.1	14.9	20.6	-13.9	43.9	48.4	53.6	1.0	12.9	12.7	0.0	5.9	5.7
40	12.1	16.8	23.4	-11.9	45.9	50.2	56.0	3.2	15.2	15.1	0.7	6.4	6.3
45	14.2	18.9	25.4	-9.8	47.7	52.1	57.2	5.1	16.9	16.8	0.9	7.2	7.1
50	16.3	21.2	27.0	-7.7	49.2	54.3	60.2	6.7	18.6	18.6	1.2	7.4	7.3
60	20.1	25.0	30.9	-3.9	52.2	56.9	62.0	9.6	21.7	21.7	1.7	7.5	7.4
70	21.9	26.4	34.1	-2.1	54.4	59.4	64.0	11.8	24.0	23.9	2.0	8.0	8.0
80	22.3	26.7	33.7	-1.7	55.8	60.8		13.7	25.8	25.7	2.3	8.4	8.3
90	22.3	26.6	33.7	-1.7	57.4	61.9		15.0	27.3	27.3	2.2	8.3	8.2

Figure A-3. Interference from LMDS Hub into the POCS as a function of elevation angle to the POCS

Elev	CV Sub 1	CV Sub 2	CV Sub 3	CV Sub 1-25	END Sub 1	END Sub 2	END Sub 3	HP Sub 1	HP Sub 2	HP Sub 3	TI Sub 1	TI Sub 2	TI Sub 3
0	0.2	3.1	7.3	-14.8	36.3	36.7	40.1	-7.5	1.1	-1.0	-9.0	-1.8	-6.5
1	0.2	3.0	7.3	-14.8	36.2	36.7	40.1	-7.5	1.1	-1.0	-9.0	-1.8	-6.5
2	0.1	3.0	7.2	-14.9	36.2	36.7	40.1	-7.6	1.1	-1.1	-9.1	-1.9	-6.6
3	-0.1	2.9	7.1	-15.1	36.5	36.7	40.1	-7.6	1.0	-1.1	-9.3	-2.0	-6.7
4	-0.3	2.7	7.0	-15.3	36.4	36.7	40.2	-7.6	1.0	-1.1	-9.4	-2.1	-6.8
5	-0.5	2.5	6.9	-15.5	36.4	37.2	40.3	-7.7	1.0	-1.1	-9.7	-2.0	-6.9
6	-0.5	2.4	6.8	-15.5	36.3	37.3	40.4	-7.7	1.0	-1.0	-9.7	-2.1	-6.7
7	-0.8	2.3	6.8	-15.8	36.4	37.4	40.6	-7.6	1.1	-0.9	-9.9	-2.2	-6.8
8	-0.9	2.5	7.1	-15.9	36.5	37.6	40.9	-7.6	1.2	-0.7	-10.1	-2.3	-6.8
9	-1.1	2.4	7.1	-16.1	36.6	37.9	41.3	-7.4	1.8	0.0	-10.0	-2.3	-6.7
10	-0.9	2.6	7.6	-15.9	37.3	38.9	43.0	-7.1	2.1	0.4	-10.0	-1.9	-6.4
11	-0.7	3.2	8.6	-15.7	38.9	41.5	45.5	-6.1	4.2	3.0	-9.7	-1.1	-5.4
12	-0.1	4.1	9.8	-15.1	40.6	44.5	50.0	-4.7	6.5	6.1	-8.9	0.0	-4.0
13	0.2	4.7	10.2	-14.8	41.1	45.1	50.6	-4.3	7.0	6.7	-8.2	0.7	-3.2
15	0.9	5.4	11.1	-14.1	42.1	46.1	51.5	-3.7	7.6	7.3	-7.0	2.2	-1.7
20	2.4	7.0	12.9	-12.6	43.9	48.1	54.4	-2.9	8.7	8.5	-4.0	5.3	1.5
25	3.4	8.0	13.8	-11.6	45.3	49.6	55.9	-2.2	9.5	9.4	-3.2	6.2	2.3
30	4.3	9.1	14.8	-10.7	46.2	51.0	56.3	-1.6	10.2	10.1	-2.6	7.1	3.2
35	5.0	9.9	15.6	-10.0	47.3	51.8	57.0	-1.1	10.7	10.6	-2.1	7.5	3.6
40	5.6	10.3	16.9	-9.4	48.1	52.4	58.1	-0.6	11.4	11.3	-1.5	7.7	4.1
45	6.7	11.4	17.9	-8.3	48.8	53.1	58.1	-0.2	11.5	11.5	-1.3	8.2	4.9
50	8.4	13.3	19.1	-6.6	49.3	54.3	60.3	0.1	12.0	11.9	-1.0	9.1	5.1
60	9.2	14.1	19.8	-5.8	50.5	55.1	60.2	0.6	12.8	12.7	-0.5	9.4	5.2
70	9.0	13.5	21.2	-6.0	51.2	56.2	60.7	0.9	13.0	12.9	-0.2	10.1	5.8
80	8.9	13.3	20.4	-6.1	51.4	56.4		1.1	13.1	13.0	0.1	9.9	6.1
90	8.5	12.9	19.9	-6.5	52.0	56.6		1.1	13.4	13.4	0.0	9.9	6.0

Figure A-4. Interference from LMDS Subscriber into the POCS as a function of elevation angle to the POCS

APPENDIX B

LMDS AGGREGATE INTERFERENCE INTO POCS RECEIVERS CONSIDERING SPECIFIC MSA AREAS